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A review of TRIZ, and its benefits and challenges in practice

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ABSTRACT

TRIZ (the theory of inventive problem solving) has been promoted by several enthusiasts as a systematic methodology or toolkit that provides a logical approach to developing creativity for innovation and inventive problem solving.

The methodology, which emerged from Russia in the 1960s, has spread to over 35 countries across the world. It is now being taught in several universities and it has been applied by a number of global organisations who have found it particularly useful for spurring new product development. However, while its popularity and attractiveness appear to be on a steady increase, there are practical issues which make the use of TRIZ in practice particularly challenging. These practical difficulties have largely been neglected by TRIZ literature.

This paper takes a step away from conventional TRIZ literature, by exploring not just the benefits associated with TRIZ knowledge, but the challenges associated with its acquisition and application based on practical experience. Through a survey, first-hand information is collected from people who have tried (successfully and unsuccessfully) to understand and apply the methodology. The challenges recorded cut across a number of issues, ranging from the complex nature of the methodology to underlying organisational and cultural issues which hinder its understanding and application. Another contribution of this paper, potentially useful for TRIZ beginners, is the indication of what tools among the several contained in the TRIZ toolkit would be most useful to learn first, based on their observed degree of usage by the survey respondents.

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1. Introduction

TRIZ comes from the Russian phrase "teorija rezhenija izobretatelskih zadach", which means the "theory of inventive problem solving"(Rantanen and Domb, 2008). It was developed by Genrich Altshuller (a Russian scientist and engineer, 1926–1998) and his colleagues, who studied about 400,000 technology patents and from them drew out certain regularities and basic patterns which governed the processes of solving problems, creating new ideas and innovation. TRIZ was developed originally for technology-related problems. However, it has seen application in various other fields.

In this methods review TRIZ is considered and its main concepts and methods are pointed out. In addition, the manner in which the methodology has propagated and has been applied in various fields, including non-technical fields, is outlined. A section of this method review is devoted to examining the experiences of people who have actually applied TRIZ. These experiences are gathered from a survey of TRIZ professionals and enthusiasts. The benefits they gained and challenges they faced while applying TRIZ, and the recommendations they offer for its improvement are pointed out making it much broader and informative than a typical review.

2. What is TRIZ?

Contemporary descriptions of TRIZ indicate that it extends beyond being merely a theory or a set of principles as its name suggests. TRIZ is a knowledge-based systematic methodology of inventive problem solving (Savranksy, 2000). Fey and Rivin (2005) described TRIZ as a methodology for the effective development of new [technical] systems, in addition to it being a set of principles that describe how technologies and systems evolve. Also, it has been described by Gadd (2011) as a toolkit consisting of methods which cover all aspects of problem understanding and solving. This toolkit is regarded by some as the most comprehensive, systematically organised for invention and creative thinking methodology known to man (Livotov, 2008).

TRIZ rests on the premise that technology evolution and the way to invention is not a random process, but is predictable and governed by certain laws (Souchkov, 1997; Eversheim, 2009). It is on analytical logic and a systematic way of thinking (Souchkov, 1997; Savranksy, 2000). This systematic approach provides an overall structure for the application of the collection of TRIZ tools and techniques.

Even though the TRIZ has been described in various ways – a methodology, a toolkit, a science (Barry et al., 2006), a philosophy (Nakagawa, 2001), etc., and this has the potential of creating confusion on what it actually is, what it is said to be capable of achieving remains unanimously clear. It provides a systematic approach for finding solutions to technical problems and innovating technical systems.

3. What does TRIZ offer and how does it work?

TRIZ possesses considerable advantage over other methods applied to problem solving and innovation. Methods such as brainstorming, mind mapping, lateral thinking, morphological analysis, etc., have the ability to identify or uncover a problem and its root cause, but lack the capability to actually point out solutions to the problem. On the other hand, TRIZ helps to identify problems and offers direct solutions to them, along with confidence that most (if not all) possible new solutions to the problem have been considered (Gadd, 2011).

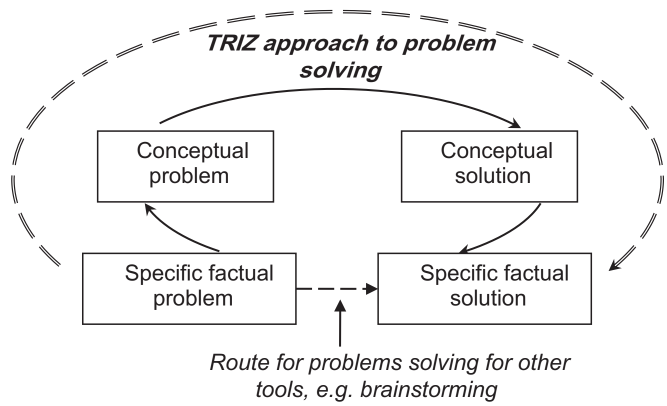

Fig. 1. TRIZ systematic approach to problem solving (the TRIZ prism) (adapted from Savransky (2000) and Gadd (2011)).

Central to TRIZ is the set of conceptual solutions to technical problems. This set of solutions is a collection of the inventive principles, trends of technical evolution and standard solutions as provided by TRIZ (Gadd, 2011). To apply any of these solutions (explained further in Section 5), a specific and factual technical problem is reduced to its essentials and stated in a conceptual format. In its conceptual form, the problem can then be matched with one or more of the conceptual solutions. The identified conceptual solution can afterwards be transformed into a specific, factual solution that answers to the original factual problem.

This approach is the overview of the TRIZ problems solving process. It is a distinctive feature of TRIZ, distinguishing it from other conventional problem solving methods (e.g. brainstorming) that attempt to find specific factual solutions to factual problems directly (see Fig. 1).

4. Main concepts in TRIZ – contradiction, ideality and patterns of evolution

The concepts of contradiction, ideality and evolution patterns introduced by Altshuller are central to TRIZ and at least one of these concepts is applied in any TRIZ problem solving process. These are explained below.

4.1. Contradiction

Contradictions are indicative of inventive problems arising from the apparent incompatibility of desired features within a system. Resolving the contradictions solves the problems. There are two major types of contradictions: technical contradictions and physical contradictions.

- Technical contradiction: This arises when an attempt to improve certain attributes or functions of a system leads to the deterioration of other attributes of that system. For example, the bigger, more powerful engine proposed for a car to increase its speed would contribute more weight to the car, which in turn limits how fast it can travel, therefore negating the desired benefit of increased speed.
- Physical contradiction: This arises when there are inconsistent requirements to the physical condition of the same system. For instance, a system might have a function (or be in a state) which is both beneficial and adverse or unpleasant. For example, an umbrella's big size helps with protection from rain, but may make it too cumbersome to carry around, and therefore, its size requirements (big umbrella for protection and small umbrella for convenience) present a physical contradiction.

4.2. Ideality

Ideality derives from "the ideal machine", an arbitrary system which has all its parts performing at the greatest possible capacity, introduced by Altshuller (1999). Ideality is a measure of how close a system is to the best it can possibly be i.e. the ideal machine (or the ideal final result (IFR)). Ideality of a system can be expressed in mathematical terms as

$$Ideality = \frac{\Sigma\ Benefits}{(\Sigma\ Costs + \Sigma\ Harms)}$$

The benefits are the useful functions provided by the system and harms are its unwanted outputs, waste products (also regarded as harmful functions) of the system.

One of the objectives of TRIZ is to increase ideality (or move a system toward the IFR). As the above equation indicates, this can be achieved by one or a combination of finding a means of increasing the benefits provided by the system, reducing the costs of resource inputs towards providing those benefits, or reducing the harmful functions (or unwanted outputs) that come with the benefits.

In innovation, defining the IFR is important since it points at the direction in which the search for new and better systems should be carried out (Altshuller, 1999). Also, it helps in understanding and identifying the optimum resources to use in delivering innovative solutions (Savranksy, 2000).

4.3. Patterns of evolution of systems

Altshuller observed that technical systems generally follow certain regularities in their development. These regularities were translated into patterns of evolution and are useful for developing good solutions to problems and predicting how systems would evolve (Rantanen & Domb, 2008). There are eight distinct trends that guide development, and each trend further divides into lines of evolution (Gadd, 2011).

Savranksy (2000) points out that it is possible to express the idea of technical evolution through the concept of ideality. It is expected that evolution brings the increase of the ideality of a system.

Understanding this and other patterns of evolution can help in forecasting technology development and identifying features that are likely to be successful in newly launched products.

5. Main tools and techniques in TRIZ

Several tools and techniques were developed by Altshuller and his colleagues in the advancement of TRIZ (Souchkov (2008) provides a concise overview and timeline of the development of TRIZ tools and concepts from 1946–2008). The ones which appear most prominent include

- 40 *inventive principles*—conceptual solutions to technical and physical contradictions.
- 76 *Standard solutions*—for solving system problems without the need of identifying contradictions. They are usually applied to correct the undesired interaction between two parts of a system.
- *Effects database*—which includes about 2500 concepts extracted from the body of engineering and scientific knowledge and applied to problem solving.
- *Separation principles*—for understanding and solving physical contradictions and points at solutions from the inventive principles relevant to the problem.
- *Contradiction matrix*—a matrix of 39 technical parameters that are arranged on the vertical and horizontal axis to interact with one another. It is used to point out the inventive principles that can be applied to solve technical contradiction.
- *Patterns of evolution of technical systems*—for identifying directions of technology development explained earlier.
- *IFR and ideality*—an arbitrary system that has all its parts performing at the greatest possible capacity, introduced by Altshuller. The IFR serves as a beacon that guides the achievement of innovative solutions.
- *Fitting*—this is the process of taking a step back from the IFR (which is a conceptual and unachievable ideal) into a realistic 'strong' solution within the constraints of the present real-life conditions (Altshuller, 1996).
- *Function analysis*—for understanding the interactions between all the components of the system and to draw out the problems arising from the interactions.
- *Substance field* (*Su-field*) *analysis*—similar to function analysis, helping to map out the entire system and point exactly to problems without adding unnecessary details.
- *Analysis of system resources*—this is the systematic search and analysis of resources within and outside the system to the benefit of the problem situation so that solutions identified are as close as possible to the ideal final result (IFR).
- *Nine windows* (also known as inventive system thinking or system operator or multi-screen diagram of thinking)—used to understand the problem or a technical system in terms of the context (or environment) in which it exists and the details of the parts within the system itself. Helps to understand how the problem (its context and details) may change over time, which is useful for locating solutions.
- *Creativity tools*—for overcoming psychological inertia (mental habits which prevent innovation, clarity of thought and thinking outside the box). These tools include size-time-cost and method of little men (otherwise known as 'smart little people').
- *ARIZ* (*the Algorithm for Inventive Problem Solving*)—a series of steps utilising an array of TRIZ tools (some of which are explained above) for finding solutions and innovations. It is reported to be most suitable for difficult and complicated problems.

Eversheim (2009) noted that the TRIZ methodology does not provide a strict sequence or specific procedure in the application of the tools. However, ways of structuring the toolkit have been suggested to provide some clarity on how the tools should be applied. Two of these are highlighted below.

Zlotin et al. (2000) classified the tools into three groups: analytical tools, knowledge-based tools and psychological operators. Analytical tools such as Su-field analysis, functional analysis, and ARIZ help define, formulate and model a problem, while the knowledge-based tools such as the 40 inventive principles, 76 standard solutions and effects provide recommendations for system transformation (i.e. problem solving). The psychological operators help to facilitate the creative and problem solving process. Moehrle (2005) provided a framework to structure the tools according to the fields of application considered important to problem analysing and solving. These fields outlined were:

- Current state – what is the current situation?
- Intended state – what is the future situation supposed to look like?
- Goals – which goals are to be fulfilled and to what degree?
- Transformation – how can the current state be transformed into the intended state?
- Resources – which resources are available and can be used?

Table 1
Classification of TRIZ tools according to application field (adapted from (Pannenbaecker, 2001) through (Moehrle, 2005).

Application field	Concept/tool/technique
Current state	Function (and object) analysis
	Contradiction
	Substance field analysis
	Evolution analysis
Intended state	Strong solution (or the most ideal outcome achievable)
Goals	Ideal final result (IFR)
	Fitting
Transformation	Inventive principles
	Contradiction matrix (and inventive principles)
	Separation principles
	Substance field analysis
	Evolution analysis
	Resource analysis
	Effects database
Resource analysis	Resource analysis (system analysis, substance field analysis and performing a systematic search for resources)

As shown in Table 1 below, the tools were put into the groups for which they were thought to be most relevant.

6. Propagation of TRIZ

From its beginnings in Russia (where Altshuller established two institutes for TRIZ development and training (Souchkov, 2008)), TRIZ has spread to more than 35 countries and is taught in several universities around the world (See a list of academic institutions at which TRIZ is being taught at http://www.etria.net/TRIZ_academic_institutions.pdf). Several global companies including Ford Motors, Procter & Gamble, and Mitsubishi have used TRIZ to develop better products more quickly (Rantanen & Domb, 2008).

Apart from enhancing innovation directly, TRIZ is also being applied in combination with other improvement and planning methods, to increase the effectiveness of the methods. Examples include the combination of TRIZ and QFD (Domb, 1998), Six sigma (Slocum & Kermani, 2006) and Kano model (Ungvari, 1999).

Efforts to apply TRIZ to management and administration issues began in the 1970s primarily for the purpose of enhancing various manufacturing processes. By the early 1980s a number of successful TRIZ applications in non-technical areas had been achieved (Zlotin et al., 2000). Non-technical areas such as marketing, psychology, sociology and education have been reported to be enjoying the impact of TRIZ as a new source of innovation (Ezickson, 2005; Rantanen & Domb, 2008).

According to Zlotin et al. (2000), basic TRIZ concepts such as ideality, contradictions and the systems approach are fully applicable to non-technical problems and situations. Analytical tools and the psychological operators are directly applicable and easily modifiable to accommodate non-technical applications, while knowledge-based tools require some process of abstraction and generalisation away from their technology-centric origins. For example, different versions of the 40 inventive principles (a knowledge-based tool) are now available for general business (Mann & Domb, 1999), finance (Dourson, 2004), marketing (Retseptor, 2005), customer satisfaction (Retseptor, 2007), service operations management (Zhang et al., 2003), software programming and computing (Rea, 2001) and education (Marsh et al., 2004). However, it has been noted that the efficiency and effectiveness of TRIZ tools are still much lower in non-technical problem solving than in technical problem solving (Yoon, 2009). Still it is argued by some that if it is applied appropriately TRIZ is capable of providing useful outcomes in practically every field (Rutitsky, 2010)

In addition, several software packages have been developed to facilitate the application of TRIZ. Some of these include are Goldfire by Invention Machine, Innovation WorkBench® by Ideation International, Guided Innovation Toolkit™ by Pretium Innovation, TriSolver (Basic and Professional) for technical and management problems by TriSolver Group and the Creax Innovation Suite by Creax which also caters for technical and management problems. Also an educational tool for teaching TRIZ called Invention Road™ by Halliburton Associates is available for academic use.

7. Issues surrounding the acquisition and application of TRIZ in practice

To provide a practice perspective of TRIZ, a survey of TRIZ enthusiasts was carried out. This brought some of the issues and challenges surrounding the acquisition and application of TRIZ knowledge into the limelight based on real-life experiences. The survey was carried out using an online survey tool, which made the questionnaire easily accessible to the potential respondents. The questionnaire was administered to two LinkedIn groups that had been formed for the purpose of understanding and applying TRIZ in practice. The groups consisted of TRIZ enthusiasts and practitioners, and industry professionals from several parts of the world.

The questionnaire requested the respondents to base their entries on their actual experiences to give a realistic and practical appraisal of the method in four areas:

- Application areas: It asked respondents to identify ways in which they have applied TRIZ and their perceived view of the applicability of TRIZ to a range of fields (technical problem solving, innovation, strategy formulation, business management and any other field in which they might have applied the methodology).
- Tools applied: Respondents were requested to indicate how often they applied an array of tools from the TRIZ toolkit. This was to give indication of the tools that were used most often which could then serve as an indicator of which ones they found easy or efficient to apply.
- Benefits and challenges: In addition they were asked to identify specific benefits they had gained from TRIZ application, and point out the challenges they faced in applying the methodology.
- Overall impact and recommendations: They also were asked to rate the overall impact and effectiveness of applying TRIZ concepts and tools on their process and recommend steps that can be taken to improve the experience of applying the method.

Forty complete responses were received and the results are presented next.

7.1. Application areas

Four broad TRIZ application areas were considered in the survey:

- Technical problem solving
- Innovation
- Technology strategy (forecasting and planning)
- Business management.

Respondents were given the opportunity to enter additional specific application areas.

As shown in Fig. 2, the majority of the respondents applied TRIZ in technology-oriented fields: problem solving, innovation and strategy related areas. Only 10 respondents applied TRIZ to management issues and problems. Application areas that fell under the 'Other' category specifically included cultural arts, book writing and book translation, process improvement, teaching and training, logistics, business model redesign, sports and government. A respondent also indicated the use of TRIZ for dealing with personal problems.

On average, the results showed that respondents thought that TRIZ was most applicable to technical problem solving and innovation, and less to technology strategy and business management.

7.2. Tools applied

The survey responses shown in Fig. 3 indicate which of the various tools and TRIZ concepts are applied most often (and therefore providing an insight into which might carry the most importance, or may be easiest to use). All of the respondents indicated that they had applied the 40 inventive principles, which also appears to be a tool used very often (with 30 of the 40 respondents indicating that they used the tool often or always). Others tools that fall within this group of tools used often were ideality/IFR, contradiction matrix, patterns of technical evolution, function analysis and su-field analysis. Those that appear to have moderate application are 2500 effects, the standard solutions, and nine windows. A sizeable proportion of the survey sample had never used ARIZ and smart little people before.

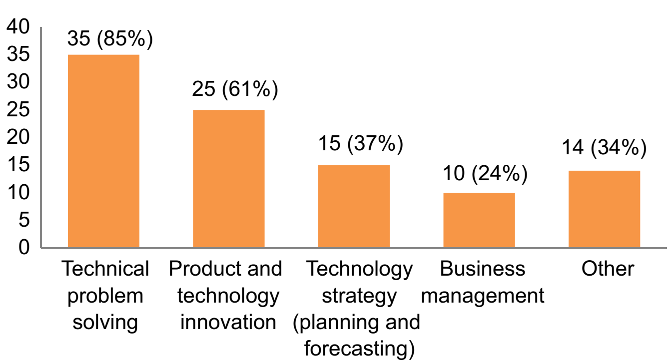

Fig. 2. Number (and percentage) of respondents indicating how they have applied TRIZ.

Combining the number of 'always' and 'often' responses for each method gives an indication of frequency of use of different tools based on the survey sample. The results are arranged in descending order in Fig. 4.

7.3. Benefits associated with applying TRIZ

The respondents identified over 100 benefits that were grouped into the following categories (see Table 2):

- *Approach to problems*: Respondents indicated that TRIZ provides a structured approach to problem solving, which prevents erratic brainstorming and search for solutions. The respondents also indicate that TRIZ helps identify and clarify problems and provide good solution hints.
- *Idea generation*: It was also indicated that TRIZ provides useful and usually novel solutions. Apart from the quality of ideas, TRIZ helps to generate more innovative ideas than would have been generated otherwise.
- *Innovation and new solutions*: TRIZ provided breakthrough innovation and solutions and new concepts for development.
- *Speed*: the resolution of problems and arriving at innovative solutions was achieved in shorter times, because it became possible to identify the problems and focus on them quickly.

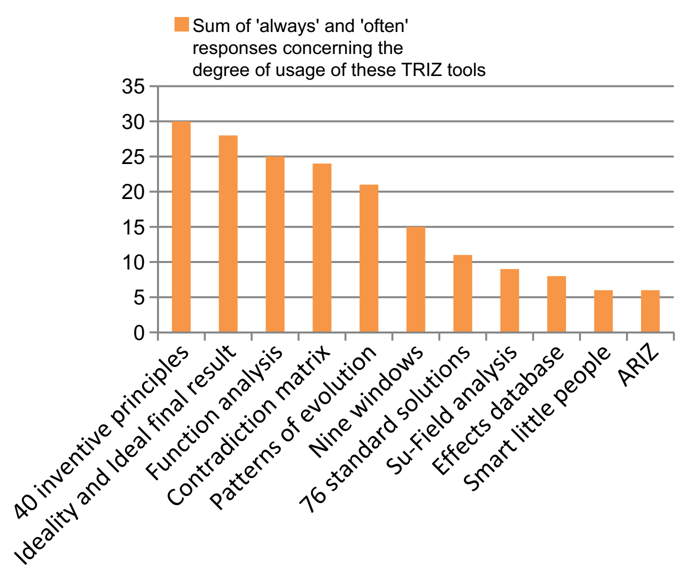

Fig. 4. Degree of usage of some TRIZ tools (survey results).

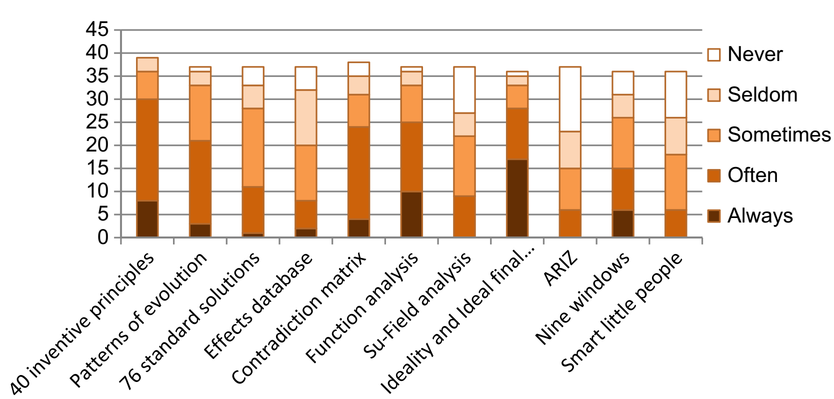

Fig. 3. Frequency of method application (result from survey).

Table 2
Benefits associated with TRIZ application (survey responses).

Categories	Responses		
Approach to problems	Methodological approach to innovative problem solving	Constructive brainstorming	Rational/structured thinking
	Provides structure	Structured procedures	Standards are better than erratic search for solution
	Useful for identifying and resolving contradictions (or problems)	Right problem	Clarify the problem
	Can be used to solve difficult problems	Release of psychological inertia	One can come out of mind's inertia
	Practical	Gives good hints	Scientific solutions data
Idea generation	Useful for generating new ideas	Provides non-obvious point-of-view	Novel ideas
	More futuristic ideas	More ideas	New ideas. Otherwise you would not have thought of.
Innovation and new solutions	Breakthrough solutions	Innovation	New process implementation innovation
	WOW solutions	Inspiration for design solutions	Generate additional/innovative possible solutions
	Applying principles and trends to find creative solutions.	New concepts for development.	Applying analogous solutions from other disciplines.
Speed	Rapidity	Fast	Shorten(ed) resolution time.
	Focus	Fast innovation process.	
Looking into the future	Forecasting	Predicting the next big jump using trends and nine windows	Foreseeing technology evolution
Teamwork	Common language among participants	Effective teamwork	Clear language and framework for communicating problems and solutions
	Teamwork	Allows problem evaluation in the group	Drive and organise solution effort
	Improved group analysis and discussions	–	–
Others	Shrink system size without decreasing performance	Less cost associated with problem solving	Useful for deconstructing patents
	Competition (provides peculiar solutions quickly enough which put the organisation in a competitive position)	Selecting the best technologies	Connection with other techniques and methodologies

Table 3
Challenges associated with TRIZ application (survey responses).

Categories	Responses		
Nature of the methodology	TRIZ has been engineered by engineers for engineering—in many ways it is over-engineered	Very structured and word-centric, not easily adaptable to visual or intuitive thinking styles	Some of the tools are too artificial and time consuming but have low effectiveness.
	Comes across as an elitist and arcane methodology		
Difficulty in acquisition and application	"We trained thousands of people in TRIZ principles and processes at (—)[a], yet only a handful became practitioners. WHY?"	Difficult to train people	People do not understand TRIZ tools
	Different skill levels for each tool	Tools are not easy to get [to understand]	Diversity of methods.
Inordinate time requirement	Requires unusual commitment and enthusiasm	Takes time to get used to the syntax	Time needed to implement TRIZ.
	Needs time for facilitation and training	Patience of mind is important to explore the approach	Must (have) practical experience in TRIZ usage.
Lack of standard	Knowing when to use TRIZ	Selecting the right tool	Lack of standardized good practice.
	Lack of rigorous standards	Too many options to approach each situation	
Organisational issues	Resistance to a toolkit	Organisational resistance	Creative people not wanting other people to be as creative as them – gate keepers within the companies wanting to own TRIZ to themselves.
	Convincing people the worth of TRIZ	Working in teams with people not knowing TRIZ	Rejection of approach by uninitiated.
Cultural issues	Russian thinking is not at all like Western thinking	Russian TRIZniks sneer at Western approaches to TRIZ and demand certification on their terms	

[a] Name of multinational company removed for confidentiality reasons.

- *A future view*: TRIZ provided respondents with a view of how technologies would evolve in the future and be put into consideration while planning for the future.
- *Teamwork*: TRIZ appears to have an effect of improving the effectiveness of teams. It provides a common language for problem solving within the group.
- The deconstruction of patents was also identified as a useful application of TRIZ.

7.4. Challenges associated with TRIZ

Challenges associated with the acquisition and application of TRIZ knowledge was gathered from the respondents (see Table 3):

- *Nature of the methodology*: for some of the respondents, the TRIZ methodology is too rigid and difficult to adapt for application in a variety of situations. Also mentioned was that the deep understanding of the method appears to be guarded, perhaps too jealously, by the 'elites' who have the knowledge.

– *Difficulty in acquisition and application of TRIZ knowledge*: challenges were faced in understanding TRIZ as a result of the difficulty of the methodology.
– *Inordinate time requirement*: TRIZ appears to require deep understanding and requires some preliminary practical experience before producing effective results. The time required to properly understand the methodology also appears to be outside the reach of many people who would like to learn and apply the method.
– *Lack of a standard*: some respondents expressed frustration over the absence of a standardized best-practice guide for the methodology. The large number of methods and multiple possible approaches to problem solving also made it difficult to identify how best to apply the tools.
– *Organisational issues*: TRIZ may not be readily accepted and absorbed by an organisation. The respondents indicate that the adoption of TRIZ still faces a substantial level of scepticism.
– *Cultural issues*: some respondents express concern regarding the lack of agreement between the classic Russian TRIZ community and western TRIZ community on what constitutes TRIZ and how it should be taught.

7.5. Feedback of effectiveness of the methodology

Despite the challenges expressed, responses depicted that the feedback and satisfaction received as a result of applying TRIZ were largely positive (24% pointing out it was extremely positive, while 62% indicated it was merely positive). 11% indicated that TRIZ provided only average satisfaction while 3% (one respondent) gave a rating of poor.

7.6. Recommendations for TRIZ improvement

Respondents were asked to give recommendations on how the application experience of TRIZ can be improved. Naturally, most of the recommendations given were in response to the previously identified challenges. These are grouped into 3 categories as indicated below.

– Simplification of TRIZ and ease of learning.
- Reducing the complexity of TRIZ to get beginners started, and at the same time not to make it too simplistic.
- Finding ways to teach TRIZ to people with non-technical backgrounds.
- Overcoming the elusiveness of Altshuller's genius (due to the language barrier and challenge attributed to the abstract and metaphoric nature of the Slavic Russian dialects in which many of his TRIZ books were written). It was suggested that this could be achieved by making TRIZ more visual (e.g. an approach called VizTriz) to make the learning and application of TRIZ principles and trends less word-centric and more visual, reducing the typical learning barriers created by language (see Ross, 2006).

– Cooperation and communication:
- Better cooperation between TRIZ beginners and experienced TRIZ users to facilitate learning.
- Increased awareness of how TRIZ has been applied and found useful.
- More global co-operation and exchange of information to make best practices available to all.

– Creation of a TRIZ standard
- Finding ways to identify which tool(s) are most effective for each typical situation in order to help TRIZ beginners achieve results quickly.
- Finding a system or framework to structure and guide the application of TRIZ.
- Arriving at a standard and unified methodology for TRIZ.

8. Discussion

The advantages of TRIZ identified by the survey respondents resonate to a great extent with the benefits already highlighted in TRIZ literature. TRIZ provides a structure to thinking and brainstorming when used in a group that leads to more effective teamwork. Ideas are generated faster, ultimately leading to shorter innovation lead times. TRIZ provides a basis for foreseeing how technical systems and technologies develop. Challenges experienced with TRIZ include difficulty associated with its learning and application.

A full understanding of TRIZ requires substantial investment in time and resources, due to its extensive scope and "mysterious" nature (Ezickson, 2005). Part of the mystery referred to by Ezickson (2005) is the difficulty in choosing the right tools from those that are available within TRIZ. Applying the wrong set of tools often results in a waste of effort (Rutitsky, 2010).

One can argue that confusion over knowing what methods to apply results from the apparent lack of structure or clear instructions within TRIZ on when and where to apply each of its tools. Even though ARIZ was developed for this reason, i.e. to provide a step-by step problem-solving framework using TRIZ tools, it does not contain all the tools available in TRIZ (leaving many still the state of confusion) and is regarded as being too complicated for most problems.

Difficulty applying TRIZ is also attributed to reasons beyond the nature of its structure. According to Zlotin et al. (2000), Altshuller found that despite rigorous TRIZ training, only a small percentage of his students apply TRIZ in their professional activities. Apparently, knowledge of TRIZ needs to be combined with a creative personality to be fully effective. The Theory of Creative Personality Development (TRTL in Russian) was developed for this reason, to help people achieve a more effective utilisation of TRIZ (Zlotin et al., 2000; Souchkov, 2008). It is unclear, however, how often TRTL is combined with TRIZ. Even if TRTL increases the effectiveness of TRIZ, its inclusion adds to the already extensive body of material required to understand and apply TRIZ.

TRIZ literature continues to grow around it central concepts resulting in more TRIZ-related research papers written and available in the public domain. However, it can be difficult to differentiate between papers that are a product of deep thought and understanding of TRIZ and those that misapply TRIZ. Publications by Altshuller and other early pioneers of TRIZ would have served as trustworthy sources, but are written in Russian. Some argue that the translation of these works have failed to capture the original message and richness of TRIZ.

Examples of how organisations have successfully/unsuccessfully applied TRIZ in innovation have rarely been fed back into the mainstream of TRIZ knowledge. The examples that are provided are usually sketchy with little detail of the actual problem solving process (See the article "TRIZ success cases" at http://www.xtriz.com/documents/TRIZSuccessCases.pdf, which gives a short overview of some success stories.). TRIZ promises good innovation ideas and solutions, which many organisations see as a source of competitive advantage. Success stories may be seen as not only giving away the 'blueprint' of successful products, but also assisting competitors. Accounts of failure are also rarely shared by organisations. In the absence of this type of information it is difficult to judge how well TRIZ works in practice, and whether it is worth the extensive training it requires.

Overall, TRIZ comes across as a complex methodology to many people. Attempts to simplify it have been met with scepticism (and perhaps, distrust) by orthodox Russian TRIZ scholars who consider the simplified versions of TRIZ watered-down and simplistic (Ezickson, 2005; Souchkov, 2008). This cultural challenge contributes to a lack of consensus that in turn hinders the existence of a globally acceptable standard or common language for the methodology.

Nevertheless, TRIZ is growing rapidly, especially in its application to non-technical disciplines, e.g. the social sciences. It is anticipated, that the application of TRIZ in such 'softer' areas will continue to gain momentum. What remains to be seen is if a level of effectiveness of the methodology, similar to that reported for the technical domain can be achieved in the non-technical applications. It must be realised that the possibility of misuse and misinterpretation of TRIZ within non-technical applications is very present (and perhaps very high) and this would increase the confusion surrounding the methodology. This is so because TRIZ, under the technical domain for which it was originally created, still demands proper understanding and standardisation. Non-technical translations of TRIZ depend very much on the understanding of the original techno-centric application. It is therefore suggested here that it may be more fruitful to direct effort to standardising the methodology within its technical domain, after which its propagation into non-technical disciplines is likely to proceed more effectively.

It is necessary to point out some of the effort already undertaken to ease some of the challenges highlighted. Cameron (2010) and Gadd (2011) have both provided frameworks to guide TRIZ users on when and where to apply TRIZ tools. The International TRIZ Association, Altshuller Institute for TRIZ Studies and European TRIZ Association defined a TRIZ body of knowledge (Litvin et al., 2005). These frameworks and definitions should ease some of the complexity and confusion associated with the methodology.

9. Conclusions

This review of TRIZ outlines its benefits and challenges. TRIZ appears to be a complex approach that requires substantial effort and commitment to understand and lacks an accepted standard for its application.

TRIZ is enigmatic in nature. While it seems to offer clarity to problem solving and innovation, there is great confusion on how to approach it and what exactly it embodies and this makes it difficult to fully grasp.

Nevertheless, the benefits of the methodology—its ability to yield innovative ideas and solutions—remain prominent and appear widely accepted. Organisations interested in pushing the boundaries of innovation and remaining competitive should consider this approach if they have the means and patience to understand it and embed it in their innovation strategy and processes.

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